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ABSTRACT

After a three-year study of scientific and technical communications, the Scientific and Technical Communication (SATCOM) Committee concluded that future communication needs will necessitate strengthening the diverse information network now being employed. The SATCOM Report attempted to do this by indicating areas in which greater effort was necessary, by defining roles and responsibilities, by encouraging their acceptance, by advocating certain broad policies in management and planning, and by proposing a way of effecting greater coordination. To implement the committee's objectives, 55 recommendations were developed which dealt with the management, performance, and economics of the vast, interrelated communication system within the sciences and technology. These recommendations were discussed in the synopsis under five general areas: (1) Planning, coordination, and leadership at the national level, (2) Consolidation and reprocessing-services for the user, (3) Classical services, (4) Personal informal communication, and (5) Studies, research, and experiments. (RR)

NATIONAL ACADEMY OF SCIENCES
NATIONAL ACADEMY OF ENGINEERING

A SYNOPSIS

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SCIENTIFIC AND TECHNICAL COMMUNICATION

A Pressing National Problem and Recommendations for Its Solution

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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SCIENTIFIC AND TECHNICAL COMMUNICATION

A Pressing National Problem and Recommendations for Its Solution

A SYNOPSIS
OF THE REPORT OF THE
COMMITTEE ON SCIENTIFIC AND TECHNICAL COMMUNICATION
OF THE
NATIONAL ACADEMY OF SCIENCES–NATIONAL ACADEMY OF ENGINEERING

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Introduction

Our three-year intensive look at scientific and technical communication showed us a diverse and pluralistic network of communication activities that, though often criticized, functions reasonably well. But if this complex network is to be effective in meeting the ever-growing number of demands made on it, certain courses of action are essential. Scientific and technical societies must appreciate their crucial role in communication activities and take immediate steps to fulfill it. The capabilities of the for-profit information-handling organizations should be recognized and fully utilized. Sponsors of research-and-development work must realize that making results accessible and adapting them to the contexts in which they can be applied are integral parts of such work. The increasing number of special user groups with common information needs must be served more efficiently. Efforts to sift, evaluate, compile, and consolidate the rapidly expanding store of information require increased emphasis and support. Finally, and most crucial, new mechanisms and policies are necessary to coordinate and guide the scientific-and-technical-communication efforts of private for-profit and not-for-profit organizations and of the government during this era of burgeoning activity and rapid change.

Scientific and technical information is the main product of *research,* for which the annual expenditure in the United States is more than $5 billion a year, and of certain areas of *development.* (The national expenditure on research and development, private and public, is now above $27 billion a year in the United States.) Further, it is an essential input to:

1. All new research
2. All new development

3. Most of the applications of research and development—new or already at hand—to our manifold needs

This information—very diverse in kind and addressed to widely different audiences—is the base for further steps ahead; it is the lifeblood of progress. The effectiveness of future work in universities, government laboratories, and industry depends on maintaining a vital flow of scientific and technical information, a task for which increasingly efficient means of information transfer are needed.

Information costs are usually no more than a few percent, at most, of the cost of doing scientific and technical work. Such work must build upon both past and current information, but much evidence indicates that the use of this information is far from optimally efficient. Therefore, it is clear that if measures can be found that will significantly improve the handling and application of information, these measures will pay for themselves many times over, even though they may involve costs substantially greater than present information-related expenditures.

Today we are experiencing rapid changes that affect the vital flow of scientific and technical information: first, the tremendous growth in scientific and technological effort and the resulting greatly expanding volume of useful information; second, the increasing complexity of concepts and the resulting new links and interdependencies among established and emerging disciplines; and third, new and intensifying demands for the rapid and efficient application of scientific knowledge to useful ends.

Since all these factors create and heighten the problems of communication, there is pressing need here, as in so many other areas, for the proper mixture of research, development, planning, and management.

It would be easy, of course, to emphasize any one of these aspects to the exclusion of others. Computers will have a major impact on the transfer of scientific and technical information, but they will begin, as they already have, by doing things we have long done by hand. Here, as elsewhere, their uses will be limited by costs. Today their importance is greatest for research.

Inexpensive photoduplication is available today in many forms, yet its impact on the transfer of scientific and technical information has just begun to be felt. Its current importance is greatest for development and planning.

The diversity of user needs and the changes that simultaneously force specialization and a broader horizon on many scientists, engineers, and practitioners have been too little recognized, and their implications are too little appreciated. Their importance is greatest for current planning and future management.

Problems of growth, overlap, coordination, and economic choice challenge management today wherever scientific and technical information is handled. There are no shortcuts that will eliminate any of these major problems or that will take full advantage of any of these major opportunities.

A reasonably effective, increasingly challenged, pluralistic system of information exchange exists today and continues to develop. There is need for guidance of its evolution, for increasing recognition and acceptance of responsibility by all the organizations—governmental, scientific, technical, and for-profit—involved, for more-effective coordination and for broader understanding of problems and opportunities.

In scientific and technical information, the days of the computer, the photoduplicator, and the printing press will seem different to both users and spectators. But the importance of economics, the vital role of organizations, and the need for increasing coordination of effort will characterize all these stages in the evolution of communication.

The Nature of the Problem

For decades—even centuries—the rate of production of scientific and technical information has been growing in geometrical progression. In the present century, except for dips during the two world wars, the amount of new research published has been doubling every ten to fifteen years. Already the figures have become staggering—roughly 40,000 research papers a year in physics, several times that number in chemistry, biology, and agriculture, even more in medicine, and perhaps as many as two million in all fields of science and technology taken together. These reports appear in some 30,000 different specialized journals.

An accelerating growth of this sort, of course, characterizes many aspects of the world economy and culture—for example, the growth of world population. With information as with population, the more rapid the growth, the more serious the problems that accompany it. And few things have been growing as rapidly as the fund of scientific and technical information.

But this is only part of the story. While the growing volume of material is forcing the specialist to narrow the range of subjects with which he maintains contact, the increasing sophistication of knowledge has caused fields that were formerly considered relatively unrelated to become interdependent. As a result, the scientist, engineer, or practitioner must broaden his interests and awareness. As an illustration, a theoretical physicist directing a program of basic research on electrical conductivity of metals in the 1930's could have kept in touch with most of the current developments useful to his work by scanning about 200 papers a year, most of them in electrical conduction in metals or general solid-state theory. Today, such a man has to be aware not only of the substantially greater amount of literature in his former central area of interest but also of a significant amount in certain other fields that he could previously have ignored (e.g., magnetism and optics) as well as in new fields that did not even exist in the 1930's (e.g., radiation damage and magnetic resonance).

There are still further complications. Emerging fields and subfields mean new and diverse groups of users with special information requirements, many of which relate to a particular subject area and some of which cut across several disciplines. Further, the information needs of scientists, engineers, and practitioners vary markedly with the nature of their numerous types and combinations of responsibilities, such as design, development, teaching, basic research, administration, and marketing.

If it could be economically feasible, each worker should have his own hand-tailored information system or systems, but the time when we can afford to supply hand-tailored access for an individual or a very small group is not yet in sight. What can be done for groups of reasonable size, a thousand or so, is a different matter. It is already feasible, and the need is urgent, to provide specialized access to information for professional groups of this size with common information requirements.

Such special user-oriented services would build upon the foundation of journal, book, and technical report literature and upon the access services (e.g., abstracts and indexes) already developed for this literature. They entail review, consolidation, or reprocessing of such products and focus on making needed information readily available and facilitating its application in special contexts. Though consolidation and reprocessing are essential if we are to ensure effective use of the rapidly accumulating store of scientific and technical information, such activities have failed to keep pace with the production of such information and with the rapid proliferation of user groups and user needs.

Efforts to cope with these specific aspects of the information problem have resulted in a variety of organizational, economic, and technological

arrangements and methods. As a result, scientific and technical communication constitutes a heterogeneous complex of activities that have emerged in response to locally perceived needs and opportunities rather than having developed in an orderly and carefully planned manner. Opportunities for cooperation are often missed; at the same time, many needed services are not performed because they "fall in the cracks" between the domains of existing organizations.

For at least two decades, many people have been growing more and more concerned about how to deal with these scientific-and-technical-information problems. Awareness of such problems has developed only gradually among the scientists and technologists who augment and apply this information, and concern is still more widespread in some fields than others. In the federal government, however, awareness and concern developed more rapidly and recently. Although the stewardship of information was specifically mentioned in several of the legislative acts to establish various science-and-technology-oriented agencies in the early postwar years, it was only in the late 1950's, with the reappraisal of the nation's scientific and technological effort, that a series of major studies of scientific-and-technical-information problems were sponsored by the legislative and executive branches of the federal government. Such problems became the focus of the hearings and reports of a number of special committees and subcommittees of the U.S. Senate and House of Representatives as well as of a series of special panels and task groups appointed by the executive branch of the federal government. Among the major results of governmental efforts to cope with the growing information problem were the establishment of the Office of Science Information Service of the National Science Foundation (NSF), to foster the development of more-effective information services in not-for-profit private organizations, and the creation of the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology, to effect greater coordination among the diverse information-handling activities of federal agencies.

The efforts of COSATI have gone far toward introducing standard procedures and greater coordination of effort among the information programs of federal agencies. But there has been no analogous coordination of the still more diverse information activities of private groups. No federal agencies have been in a position to effect such coordination, although the need for a nonfederal coordinating body came to be recognized by the NSF, the Office of Science and Technology, and many private groups. In recognition of this need, the NSF requested the National Academy of Sciences, in cooperation with the National Academy of Engineering, to establish a committee to make an intensive survey of the present status

and future requirements of the scientific and engineering community with respect to the organization, flow, and transfer of scientific and technical information and to recommend needed policies and courses of action based on its findings. As a result, the Academies established our Committee—the Committee on Scientific and Technical Communication (SATCOM)—early in 1966.

The creation of SATCOM was a move toward specific implementation of some general policies recommended by several previous study groups. Its mandate called for, first, a very broad and detailed study of the many ways in which information is handled and facts and insights are transmitted, and second, the formulation of specific recommendations to private organizations and to the federal government, particularly with regard to the relation of federal to private activities. Ample time was available, and SATCOM's nongovernmental base enabled us to consult a representative sample of scientific-and-technical-communication activities.

We began our work by surveying in depth each of a large number of private and governmental information-handling activities, often by visiting their headquarters. To assist in the resolution of some currently acute issues as well as to develop perspectives on possible coordination procedures in certain special fields, we organized four *ad hoc* task groups. Finally, to sound out the opinions of the scientific, technical, and information-handling communities, and to secure their broad participation in the formulation and resolution of policy questions, we selected and maintained contact with a group of about 200 key individuals from diverse institutions and disciplines, called SATCOM's Consulting Correspondents. The following sections present the major conclusions and recommendations that have evolved from this background.

The Climate for Solution: Major Emphases of the SATCOM Report

The principal impression received from our three-year intensive look at scientific and technical communication was that of diversity—diversity in information-handling activities, in the economics and techniques of operation, in functions, and in users. And we concluded that such diversity

was not only characteristic but essential. It facilitates the flexibility, the sensitivity and responsiveness to user needs, and the innovative, forward-looking approaches required for effective scientific and technical communication. Further, though the heterogeneous complex of communication activities in the United States has been criticized frequently and on many counts, there is no evidence of critically inefficient operation. Therefore, we accepted this diversity and concentrated our efforts not on reducing or eliminating it but on maximizing its strengths and overcoming its weaknesses. We have attempted to do this by indicating areas in which greater effort is necessary for adequate performance, by defining roles and responsibilities, by encouraging their acceptance, by advocating certain broad policies in management and planning, and by proposing a way of effecting greater coordination.

A PRESSING NEED

A crucial area in which efforts are inadequate to meet current demands, much less those of the future, is that of providing what we call "need-group services." As we have mentioned, effective service to professional groups, each numbering a thousand or so and having common information requirements, is a first approach to reaching the goal of individual service geared to each user's specific needs. Such need groups are especially prevalent among engineers and practitioners, and the tailoring of information to facilitate prompt access and rapid application in such groups must receive top priority.

The provision of specialized services to foster the application of scientific and technical information in particular contexts depends, on the one hand, on sifting, evaluating, simplifying, and consolidating the ever-expanding store of primary information, and on the other, on reprocessing and repackaging the products of secondary (abstracting and indexing) services.

The need to allocate greater effort to compilation and consolidation activities was emphasized some years ago by the Weinberg Panel of the President's Science Advisory Committee. Following the publication of that panel's report in 1963, the number of centers providing critically evaluated data compilations has grown, and the production of various types of reviews and consolidations has increased in various scientific and technical disciplines. However, the current production of reviews and data compilations is but a fraction of the present requirement, and the need is steadily growing. In addition, there is evidence that current reviews tend to cover the literature much less thoroughly and compre-

hensively than was formerly the case. Therefore, we re-emphasize that the functions performed by critical review and compilation—digesting, simplifying, and repackaging for specific categories of users—are essential if information is to be used effectively.

Reprocessing the products of secondary access services is as important as consolidation in the provision of special need-group services. Sorting abstracts (available in machine-readable form), rearranging and merging selected ones, and providing copies of the results in readable form are basic steps in serving specialized areas of need. Therefore, the immediate task in developing diverse need-group services is to stimulate the reprocessing of abstracts and associated indexing information prepared by basic abstracting and indexing services. To do so will necessitate restructuring the support of these basic services in ways that will enable them to make their products available for reprocessing roughly at output (reproduction and distribution) costs without endangering their solvency.

For the near future, we regard the expansion of consolidation and reprocessing activities as the most vital thrust in fostering the prompt and effective application of scientific and technical information.

ROLES AND RESPONSIBILITIES

It is not sufficient, however, to point only to what must be done; we must look also at the allocation and sharing of responsibility for getting it done.

The scientific and technical societies, which originally were called into being to provide more-effective channels of communication and continuing education in the disciplines they represent, have a crucial role to play. Because their membership includes the principal generators and users of scientific and technical information, they are uniquely able to collect, organize, and assure the quality of the information that they distribute through their meetings, their primary publications programs, and their secondary abstracting and indexing services. They are also responsible for fostering continuity and progress in the various domains of science and technology that they serve. We have tried to challenge the scientific and technical societies to explore to the fullest their role in scientific and technical communication and to accept their responsibilities, a few of which are: (a) improving the quality, timeliness, and techniques of producing and distributing primary literature; (b) assuring adequate basic abstracting and indexing of this primary information; (c) stimulating reprocessing and repackaging of primary and secondary information for

special user groups; (d) conducting performance and evaluation studies of the information services they sponsor; and (e) assuring the participation of qualified scientists, engineers, and practitioners in these and other exploratory and innovative studies.

Equally vital is the role of the for-profit organizations. Because their survival and growth depend upon their ability to recognize, understand, and adequately serve users, and because of the management and marketing capabilities they have developed, they can assist scientific and technical societies and the federal government in the development and provision of needed information services. Traditionally, they have been especially effective in developing various specialized highly user-oriented services needed not only by researchers but also, and especially, by practitioners. They are well qualified to fulfill a major role in reprocessing and repackaging information to speed its application in specific contexts, and their capabilities should be recognized and fully utilized.

The federal government clearly has a responsibility to support the scientific-and-technical-information activities that are required for the accomplishment of its various missions. Some of these present specialized information-handling problems, the magnitude of which requires highly structured and centrally managed information programs. Therefore, a number of federal agencies, for example, the Atomic Energy Commission and the National Aeronautics and Space Administration, have statutorily assigned information functions relating to their missions. Others, such as the Department of Defense, require broad and diverse information programs in support of the numerous teams and organizations with which they work. Of particular importance at the present time are the slowly knitting, massive programs of recent years that deal with such major social concerns as natural resources, education, transportation, pollution, and urban problems. In these areas, the role that science and technology will play still is evolving, and so are the information programs that will be required. However, it is already apparent that data bases and information systems that are substantially more extensive than those previously supporting our major scientific and engineering ventures will be necessary in such programs.

In addition to the fulfillment of mission requirements, the federal government inevitably must provide substantial support through various agencies to scientific-and-technical-information efforts in the public interest. Obviously, such support cannot be extended without the exercise of responsible management and at least limited control. Minimizing the danger of interference of such control with a ready and adequate response to the needs and views of the scientific and technical communities being

served is a difficult task. We believe that such interference can be minimized if the support of discipline-oriented scientific and technical services does not become more narrowly concentrated within the federal government than is support of a discipline's over-all research-and-development effort. We further urge the reliance of federal agencies on existing capabilities in private organizations and the upgrading of relevant activities when necessary, rather than the duplication of such services.

In short, both governmental and private organizations have the common objective of providing information services that are increasingly sensitive to the needs of users of scientific and technical information. We urge recognition of this common objective and acceptance of a philosophy of shared responsibility between private organizations (both for-profit and not-for-profit) and federal agencies in the management of scientific-and-technical-information activities. Further, we believe that in the accomplishment of this objective, support policies should be permissive and should not automatically preclude support for any group.

Not only have we considered the responsibilities of governmental and private organizations in the operation of information services, but also we have pointed to the responsibilities of all who sponsor research-and-development work. We have emphasized, as the Weinberg Panel did in 1963, that such work is of value only when the results are readily accessible and capable of being adapted to the contexts in which they can be applied. In other words, the sponsor's responsibility for such work includes whatever steps are appropriate and necessary to assure its availability.

Users of scientific and technical information were trained and work today under conditions that offer far larger rewards for doing "new" work than for finding, through careful literature search, the results of work already done.

Opportunities for management to balance the costs of better information services against the costs of doing more new work are few and far between. Therefore, it is inevitable that information that seems costly to get will not be sought, regardless of its value, and that, when prices are lowered, making the acquisition of greater amounts of information economically desirable, these greater amounts will not be acquired.

Some rediscovery of what is already known is economically sound, but, as the amount of obvious rediscovery increases, a slow readjustment in the habits of the scientific and technical community and in its allocation of resources is to be expected.

Users of scientific and technical information are slow to change their habits of information use, usually learned in their formative years. As a

consequence, there are strong tendencies toward "in a rut" behavior and toward apathetic responses to new and more-effective services. Users find it natural to rely on the most accessible and familiar sources rather than to experiment with new ones that may require a greater initial investment of effort. An intensive and concentrated re-educational or marketing effort is often necessary to gain acceptance of worthwhile innovations.

The lack of economic balance that results from the traditional pattern of conducting the work of science and technology together with apathy and great resistance to change render the usual test of the marketplace an insufficient guide to the need for and value of information services. We dare not depend on support of information transfer exclusively on the part of users to produce a system that is in over-all economic balance.

One effort to provide a logical distribution of responsibility between generators and users and to afford financial stability to journals, in spite of fluctuations in the amount of input and the number of subscribers, is the page charge. This practice entails charging sponsors of research and development a publication fee, which is established in relation to input costs, and basing subscription fees on reproduction and distribution costs. Though supported by a 1961 policy statement of the Federal Council for Science and Technology, which allowed the payment of page charges for publication of work generated under federal research-and-development contracts, this practice was never universally employed and, as a result of current budget constraints, opposition to its use has increased. There is need for the development and trial of other feasible arrangements to support the dissemination of information and for recognition of initial publication as but one step in the process of making results available and fostering their application. Suitable procedures for funding secondary services, an area in which no single clear-cut policy of support has yet emerged, and for support of the essential consolidation and reprocessing activities also must be explored. Otherwise, the precious resources of our scientific and technical knowledge will be poorly utilized —a waste that we must not tolerate.

The entire area of the economics of information transfer and the allocation of financial responsibility for effective scientific and technical communication requires far more careful study and analysis than it has received. It is essential that operators of information programs continuously explore the possibility of establishing a closer relationship between the cost and the effectiveness of their services. Further, they must increase their efforts to overcome the "line of least resistance" behavior patterns of users faced with new and improved services.

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A PHILOSOPHY OF MANAGEMENT

To maximize the advantages of our present complex of communication activities and to illustrate the philosophy of shared responsibility—between governmental and private organizations and between generators and users—for effective scientific and technical communication, we have developed three basic principles to guide the management and planning of scientific-and-technical-information programs and services. The first of these principles is: *The management of all scientific-and-technical-communication activities must be as responsive as possible to the needs, desires, and innovative ideas of the scientific and technical groups that they serve. These activities must be sufficiently flexible to adapt rapidly to changes in user needs and communication techniques.* Because so many kinds of information must be communicated, and because there are increasingly wide variations among groups of users in regard to the types of information that they need and the forms and language in which they need it, flexibility and responsiveness must remain intrinsic to scientific and technical communication. To accomplish this objective there is need for (a) an equitable balance of influence among the managers of information programs, the generators and users of information, and those who market information products and (b) ample opportunities for interaction among these groups, both within and among various information programs. Further, *the administrative entities responsible for scientific-and-technical-information programs must be so organized and coordinated that they represent a logical and efficient division of functions, but authority over them must be sufficiently widely distributed to achieve the responsiveness we deem essential.* This second principle reflects our belief that a basic element of strength in this nation's over-all scientific-and-technical-communication effort is the participation of the members of the scientific and technical community in its development and administration. Such participation is vital in assuring flexibility and innovative approaches. A third principle is: *The planning and management of our information activities must involve constant attention to the simplification and consolidation of existing knowledge and its frequent reprocessing to adapt it to the needs of diverse users, especially those engaged primarily in the practical application of scientific and technical information.*

The planning and development of more-effective services advocated in our third principle involve exploring the potential of new computer-aided techniques of information handling and utilizing them to best advantage. Since success in this effort requires a blend of intellectual know-how and complex machine processing, shortcuts are not available, and many difficult problems, such as those related to standardization and

convertibility and to copyright, arise. We expect continued changes, probably major ones, in the near future in many aspects of scientific and technical communication as a result of such new developments as techniques of inexpensive and rapid photoduplication (full-scale and microform). And for the more distant future, we anticipate increasing reliance on the on-line use of modern electronic computer systems. Such techniques offer opportunities to make information services more responsive than ever before to the needs of diverse groups of users, but to realize this objective, the management of our information programs and services must foster imaginative innovations and must provide ample opportunities for the exploration and testing of new procedures. The awareness, interest, and participation of scientists, engineers, and practitioners of proven competence in their respective disciplines are essential to the conduct of innovative studies and the exploration of the most useful and feasible applications of new technologies. Further, the development of new services should be gradual; present ones should not be allowed to cease operation before the ability of new ones to replace them has been demonstrated.

FOSTERING COORDINATION AMONG PRIVATE ORGANIZATIONS

To build upon and strengthen the present pluralistic and decentralized scientific-and-technical-communication complex, it is essential to foster greater coordination and cooperation among its diverse components. The Committee on Scientific and Technical Information has contributed greatly to developing standard procedures and to increasing coordination among the information-handling programs of federal agencies. We see the need for a broadly representative, high-prestige, nongovernmental body to lead the private for-profit and not-for-profit organizations in the coordination of their interests and programs and to facilitate their interaction with appropriate governmental policy-making organizations. We believe that the private organizations can be guided in the development of their own patterns of coordination once a focal point is clearly designated. Therefore, we propose the creation of a Joint Commission on Scientific and Technical Communication, responsible to the Councils of the National Academy of Sciences and the National Academy of Engineering. The Commission's membership of about 20 should be broadly representative of the major scientific and technical communities and of the principal kinds of information-handling organizations. It should be

supported by an adequately staffed professional secretariat. A major responsibility of the Commission would be to maintain close and continuing contact with the communities it serves by establishing *ad hoc* committees and task groups for major problem areas and by interacting with a large number of consulting correspondents such as those who have assisted the work of SATCOM.

The Academies were selected as the optimum base for such a Commission for four major reasons: (a) They would afford ready access to maximum knowledge and expertise in science and technology; (b) they would ensure broad representation of the organizations, groups, and individuals whose efforts depend upon and influence scientific and technical communication; (c) they would facilitate the desired type of interaction with the federal government; and (d) they represent a long-standing tradition of diversified and intensive involvement in scientific-and-technical-communication activities.

The proposed Commission would be conversant with scientific-and-technical-information activities and would provide guidance useful to public and private organizations in the development of more-effective scientific-and-technical-communication programs. It would interact with (a) the membership and leaders of the scientific and technical community; (b) scientific, technical, and educational societies and institutions; (c) for-profit organizations; (d) relevant bases for the coordination of scientific-and-technical-communication activities in the government, especially the Office of Science and Technology, COSATI, and the NSF's Office of Science Information Service; and (e) other supporters of science, technology, and information services.

Its mission would be:

1. To serve the scientific and technical community by fostering coordination and consolidation of its interests in the handling of scientific and technical information
2. To serve the government by providing representatively comprehensive and authoritative information and advice on the activities, needs, and ideas of the scientific and technical community in this field

To be pluralistic, user-oriented, rapidly evolving under strong federal support—but with strong self-coordination to match the growing responsibilities of the private organizations—is, in broad outline, the pattern we advocate for the vigorous growth of scientific and technical communication.

Specific Courses of Action: SATCOM'S Recommendations

To implement the objectives outlined in the preceding section, we have developed 55 recommendations that deal principally with the management, performance, and economics of the nation's diverse but interrelated scientific-and-technical-communication efforts. Although we have tried wherever possible to place responsibility for needed action on particular organizations or agencies, we did not subject the activities of any specific group to individual criticism. We urge those engaged in developing and operating information services and in marketing their products to review the recommendations in their entirety, not only in this brief and nontechnical summary, but in Chapter 3 of our final report, in which they are presented in full with accompanying discussion.

The five general areas treated in our 55 recommendations include:

1. Planning, coordination, and leadership at the national level
2. Consolidation and reprocessing—services for the user
3. Classical services (abstracting and indexing, libraries, formal and semiformal publication, and meetings)
4. Personal informal communication
5. Studies, research, and experiments

PLANNING, COORDINATION, AND LEADERSHIP AT THE NATIONAL LEVEL

Because we believe, as we indicated at the end of the preceding section, that a broadly representative, nongovernmental body of high prestige is essential to stimulate greater coordination among private groups and to facilitate their interaction with appropriate branches of the government, the first of our recommendations calls for the establishment of a *Joint Commission on Scientific and Technical Communication, responsible to the Councils of the two Academies.*

Also mentioned in the preceding section was the basic philosophy of *shared responsibility between governmental and private organizations for the effective communication of scientific and technical information.* This is the subject of our second major recommendation, which calls on the

organizations of the scientific and technical communities to recognize the national implications of their activities and the proper role of the government and, in turn, calls on government agencies to allot a central place in the management of the information services required in support of agency missions to the scientific and technical community or in some cases to commercial information-handling organizations. An important application of this principle is found in information programs that, though needed for the accomplishment of a government-agency mission, are directed in major part to workers outside the government (i.e., information programs that are principally discipline-oriented). We advocate that *such government-sponsored but discipline-oriented programs be managed by appropriate scientific and technical societies, by federations of such societies, or, in special cases, by commercial organizations.* As an illustration, we mention the National Aeronautics and Space Administration (NASA), which fostered the creation of the American Institute of Aeronautics and Astronautics (AIAA), a nongovernmental organization of scientists and engineers. Operating under contract to NASA, the AIAA makes information on journals, books, and meeting publications in this field available through *International Aerospace Abstracts.* In addition, coverage of the worldwide technical report literature is provided through *Scientific and Technical Aerospace Reports,* which is managed by a commercial organization under contract to NASA.

A particularly important corollary of the philosophy we are enunciating is that those who support research-and-development work have a responsibility to see to it that the information so generated becomes truly available. Because it was realized some years ago that work does not properly benefit society until it is published and accessible, federal research grants now provide for support of an appropriate share of the costs of publication. But today mere publication of isolated tidbits scattered through a multitude of journals is rarely sufficient to place the totality of new results and insights on a given subject effectively within the grasp of those who should benefit from them. So we now call for acceptance of a broader responsibility and urge *sponsors of research-and-development work to recognize as integral to the support of such work the publication and processing of the information so generated for access, consolidation, and use in special contexts.*

Although to be practical our recommendations have to be addressed almost entirely to governmental and private organizations in the United States, we must never lose sight of the fact that scientific and technical communication is a world activity, not just a national one. The contribution made by the United States to the world's primary literature has

always been only a fraction of the total, and this fraction is decreasing as more countries achieve high productivity. Thus, the need for international cooperation is already great and will continue to grow. Leadership in our so-called national programs will increasingly involve the development of more-effective international scientific and technical communication; therefore, we recommend that *the policy-making groups of our scientific and technical societies encourage the managers of their major information services in the development of ways in which access and transfer activities can operate on a more truly international basis through sharing both work and products across national boundaries.* Related recommendations point to (a) the responsibility of the federal government to encourage and assist private efforts to effect international information-exchange arrangements; (b) the need for early planning by the management of international research efforts (such as the International Biological Program) for the storage and transfer of the information and data so generated; and (c) the necessity of including representatives of relevant nongovernmental information activities in U.S. delegations to internationally managed information projects.

Two final recommendations on national planning deal with special problem areas of widespread concern—copyright and standardization. Both are complex and include a wide range of problems other than those related to scientific and technical communication. Each demands careful study over its whole range. In the case of copyright, recent congressional hearings have underscored the fact that existing copyright law is not adequate to cope with the problems posed by the radical new techniques now available for reproducing documents and for storing and processing information. We believe that this field should be studied in depth before necessary new legislation is developed to deal with these problems. Therefore, we support the concept of legislative action to create a special statutory commission to study copyright problems (entirely distinct, of course, from the Joint Commission proposed in our first recommendation).

Standardization has to do with how a file of information generated by one group can be efficiently accessible to another, especially if communication between electronic computers is involved. As vast computer-based stores are already accumulating rapidly, no time should be lost in working out and securing general acceptance of carefully considered standards that will minimize technological difficulties in this kind of communication. Therefore, we advocate the creation of a special task group of the proposed Joint Commission on Scientific and Technical Communication (of the two Academies) to maintain awareness of relevant developments in standardization and convertibility.

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CONSOLIDATION AND REPROCESSING—SERVICES FOR THE USER

Often it is of very little help to a worker, be he scientist, engineer, or physician, merely to supply him with a long list of publications relevant to the problem with which he is grappling. What he needs is something that will organize and evaluate what is known about a subject and present it in language that he can understand and at the level of detail that he wants. Such consolidations of information, the preparation of which often requires great intellectual creativity, have traditionally appeared in review articles, books, data compilations, and the like. But the preparation and use of such material has not kept pace with the flood of potentially useful new information in the scientific and technical literature. So we not only call for acceptance of broader responsibilities in this area by the sponsors of research and development, as indicated in the preceding group of recommendations, but we also urge *scientific and technical societies to take major responsibility for identifying needs for critical reviews and data compilations, furthering their preparation, fostering awareness of their existence, and stimulating education in their use.* In addition, so great are needs in this area that the proposed Joint Commission should take a hand in stimulating consolidation efforts and suggesting feasible ways of promoting easier and more-efficient access to those reviews appropriate to a user's specific needs.

Another crucial area is that of providing the practitioner—the person who has the job of putting new knowledge to practical use in industry, hospitals, farms, and the like—with the types of information that he requires, presented in the language and format that will be most meaningful to him. Currently, much is written about the lag between discovery and application—between the announcement of new knowledge and its incorporation in new technological developments. The provision of specialized services geared to the needs of the practitioner, and to subfields, and cross-disciplinary areas of need, are key steps in speeding the effective use of information. We recommend that *societies whose membership includes large numbers of practitioners, especially in engineering, medicine, and agriculture, increase their attention to information programs that will ensure awareness of and access to information of particular interest to practitioners; identify and stimulate efforts to fulfill the needs for state-of-the-art surveys, reviews, and data banks; and provide for the practitioner's need for continuing education to keep up to date in special fields.* Since many of these types of services traditionally have been handled by for-profit organizations, scientific and technical societies should encourage such organizations to undertake them.

Several more of our recommendations deal with ways in which the design and initiation of special information services for diverse need groups (as defined in earlier sections) can be facilitated by scientific and technical societies, by the government, and by the proposed Joint Commission. Once such services are established, they should usually be able to gain their support from the users they serve. Private enterprise and small-group interests can be very effective in discerning and meeting the needs of diverse groups, but only if the information that has to be reprocessed for the necessary services can be made available to them on economically reasonable terms. Much of the information will usually come from the broader discipline-oriented basic abstracting and indexing services, which means that, ideally, the products of the latter services should be available to all who would like to use them at costs reflecting merely the extra effort necessary to supply the services in quantity to the new customers. Therefore, it is urgent that *those societies and agencies concerned with the conduct and support of abstracting services should seek actively to identify difficulties, find solutions, and take the initiative in proposing and testing arrangements through which an increasing contribution by the sponsors of research to the input costs of the basic abstracting services can make transfer for reprocessing financially feasible at approximately output (reproduction and distribution) costs.* The accomplishment of this objective will be neither easy nor rapid. In the interim, basic abstracting and indexing services must be responsible for launching reprocessing efforts or stimulating the effective use of their products. And scientific and technical societies must recognize and prepare to assume their responsibilities for adequate reprocessing of access information in their respective disciplines. The aid of commercial organizations should be actively sought for the fullest development of useful reprocessing services.

Even as access to reviews presents a problem, so does access to the basic abstracting and indexing services appropriate to the particular needs of diverse user groups; therefore, one of our recommendations is addressed to the exploration of means of guiding users in their choice of the indexing and abstracting services appropriate to their needs.

A considerable potential for the provision of the specialized need-group services we have described exists in the form of information analysis centers. These centers, of which over 100 are now sponsored by the federal government, have been set up to serve certain specific fields in which there are large amounts of data that require critical evaluation. Such a center typically consists of specialists who collect, assemble, evaluate, and store information about a certain subject area and make it available to specific groups of users. We feel that the capabilities of these

centers are not fully utilized, and we recommend that the proposed Joint Commission aid in identifying the major information analysis centers dealing with particular subject areas and capable of offering services to specialized need groups. It also should stimulate the exploration of ways in which such services can be made more widely available.

Two final recommendations in this section treat management problems, which, although they are encountered in all forms and on all levels of scientific-and-technical-communication activities, are especially prominent in providing highly user-oriented services. The development of adequate and continuing feedback mechanisms to assure the relevance of services and the need for increased emphasis on substantial marketing and educational efforts to overcome the "in a rut" and "line of least resistance" behavior patterns of users faced with new and improved services are highlighted in these recommendations.

THE CLASSICAL SERVICES

We include among the classical services:

1. Basic abstracting and indexing
2. Selection, acquisition, bibliographic control, reference, housing, document delivery, and other service functions of libraries
3. Formal and semiformal publication
4. Meetings

Most areas of science and technology have developed the custom of keeping track of the literature of their fields by publishing comprehensive collections of abstracts—usually one-paragraph summaries of articles published in specialized journals—and by suitably indexing this material. The increasing volume of material to be covered has caused the cost of such services to rise rapidly. At the same time, increasing subscription costs have discouraged individuals (as opposed to libraries and other institutions) from subscribing to them.

In seeking new ways to support abstracting and indexing services and to improve existing support mechanisms, special care is necessary to ensure the broad usefulness of the product and maximum responsiveness to the progress of science and technology. Two paramount issues in this context are sensitivity of management, particularly in regard to scope of coverage and adequacy of abstracting and indexing, and availability of abstracts for reprocessing.

In addition to the basic abstracting and indexing services we have de-

scribed, which systematically order for permanent reference all material published in a given discipline, numerous other services exist that are also extremely useful. Examples are listings of titles of items newly published and citation indexes, which show the interrelationship among a wide selection of items by indicating which ones cite others. These types of services differ in nature and scope from basic abstracting and indexing and need not be managed in the same way.

Our central recommendation with regard to these so-called secondary services undertakes to preserve a proper balance between the interests of the nation, and especially the federal government, in ensuring uninterrupted availability of the basic services and the advantages of leaving the management of both kinds of services in the hands of those who will be most sensitive to the needs of scientific and technical disciplines or appropriate groups of users. Our recommendation is that the *departments and agencies of the federal government fund the literature-access services that are needed for the effective utilization of the knowledge resulting from the research and technical activities that they sponsor. In so doing they should ensure (a) management of basic discipline-wide abstracting and indexing by appropriate scientific and technical societies or federations thereof, though the use of for-profit services in special cases should not be precluded; and (b) management of other broad bibliographic services (e.g., title listings) by private for-profit organizations, national libraries, or societies.*

There follow two recommendations on steps that scientific and technical societies, aided by the National Federation of Science Abstracting and Indexing Services, can take to improve the quality, timeliness, and efficiency of preparation of the necessary abstracts and indexes.

The role of libraries in the dissemination of information and in evolving national information systems was the focus of the recent intensive survey of the National Advisory Commission on Libraries. The basic import of the five recommendations presented in their report is in harmony with SATCOM's over-all approach and recommendations, two of which deal with libraries. We feel that it is imperative that library services be made much more responsive, and that there are few limits to what can be done if adequate resources are made available. However, pouring more and more money indiscriminately into libraries will not solve their complex problems. Therefore, we recommend a funding policy aimed at introducing: (a) a more-realistic reflection of library costs in the conduct of scientific and technological work; (b) a closer relationship between costs and services; and (c) more options of extra service for an extra price. We advocate *direct grants from appropriate agencies for the strengthening of research-library services, with emphasis on funding*

new and innovative services and special provisions in research grants to educational and research institutions for adequate funds for the use of needed library and information services. These funds should be provided in such a way that researchers can exercise discretion in their use and choose the services that they find most valuable. Our second recommendation with regard to libraries focuses on education—the education of users in the existing array of library services, and training programs that place greater emphasis on the operational analysis of library services.

Our next recommendations deal with formal primary publications, that is, the scientific and technical journals in which new results and discoveries are presented to the professional public. The relentless expansion in the amount of new material to be published has posed intellectual problems for the journals and has involved them in growing financial difficulties. There is pressing need for systematic study and analysis of the economics of these publications. Consequently, we recommend *studies to examine the income returned to such publications from their principal markets—users, authors, and the public—together with trends in cost factors and the impact of new technologies to guide the evolution of flexible funding and pricing policies that will be responsive to the needs of each interested party without being unduly responsive to any.* Until such data have been assembled and possible alternative funding arrangements have been convincingly tested, we urge that *sponsors of research and development continue to provide support through page charges* (see discussion in the section on "Roles and Responsibilities") *for the publication of such work.*

Several subsequent recommendations offer suggestions for reducing publication delays, using new advances in the techniques of publication, directing highly selective material to individuals or small groups, and disseminating information on "who is doing what, and where."

In addition, two recommendations deal with semiformal communication (i.e., technical reports or papers prepared for publication and circulated before their appearance in journals). There has been much controversy over the purposes of such modes of communication. Many people argue that everyone interested should have access to any information that can be supplied without having to wait for formal publication. On the other side are those who fear undermining of the tradition of placing new results in journals so that they can be identified and located for ready reference and where certain standards of quality and novelty must be met. We believe that there is merit in both arrangements and that these views are not entirely irreconcilable. Therefore, we urge (a) adequate bibliographic control, insofar as is practicable, of semiformal publications that need wide distribution so that they can be readily identified; (b)

general accessibility through storage in depositories; and (c) control of distribution to the extent necessary to protect formal publications. We also advocate a clearer differentiation between those technical reports required at certain intervals, regardless of the status of work (e.g., periodic progress reports), and substantive reports prepared when the work warrants. Additionally, standards of uniformity in the documentation of all substantive reports are needed to allow adequate bibliographic control and to foster accessibility.

PERSONAL INFORMAL COMMUNICATION

In a qualitative sense we know that personal informal exchanges play a major role in the transfer of scientific and technical information. The increasing number of informal information-exchange groups, the steadily growing tendency toward collaborative and team research, and the current emphasis on conferences, meetings, interinstitutional visits, and other occasions that facilitate informal interaction are evidence of both general awareness of the necessary role of informal communication and increasing dependence on it. Such emphasis and dependence have resulted in numerous studies to determine the characteristics, content, and functions of informal interpersonal communication. But accurate, quantitative comparison of the effectiveness of the very informal interpersonal techniques of communication with that of other communication methods and media is difficult to achieve and presents many problems. Though progress is under way in this area, far more clear-cut and comprehensive data on the ways in which informal channels operate are necessary before constructive recommendations to enhance its effectiveness can be developed. Therefore, we offer but two recommendations on this topic; one stresses the importance of providing ample opportunities and facilities for informal communication at scientific and technical meetings, and the other encourages leave and sabbatical policies that foster interinstitutional visits and exchanges of personnel.

STUDIES, RESEARCH, AND EXPERIMENTS

In a final group of ten recommendations, we suggest some studies and experiments that are urgently needed and some guidelines for their conduct. We give *top priority to the initiation of comprehensive analyses and of experiments on the functioning of different parts of the scientific-and-technical-communication network and on its over-all operation.* Efforts to develop *measures of the value of information services and ways of over-*

coming user apathy or resistance in the face of new options and services also receive major emphasis. Comparisons of various means of storage and transmission and the careful consideration of their implications for information-handling practices—for example, the question of centralized versus decentralized depositories—deserve special attention.

As we have already indicated in several places in the preceding paragraphs, a wide range of exciting possibilities for the use of new technologies in the storage, processing, and transmission of information exists. Though it may be Utopian to dream of meeting all needs by simply "asking the computer," there can be no question that the scientists and technologists of the future will be able to handle information in ways that were undreamed of because of the rapidly increasing capacity of computers to store and search vast amounts of material. Carefully planned applications and modifications based on experience will be necessary if the full potential of new technologies is to be realized. Therefore, we urge a series of major experiments involving the use of the computer in conjunction with human workers for the preparation of indexes; "evolutionary indexing" in which a small widely used file of references on some single subject area can have basic critical comments added to it by qualified users—comments that can benefit subsequent users; the development and evaluation of languages for describing the formats of files and other types of digital communication systems; and the development of standard structures for each widely used bibliographic documentary information element. The participation of highly competent scientists, engineers, and practitioners is of vital importance to ensure the relevance of such experiments to key questions and issues, coherence of effort in their conduct, and efforts to follow up and apply their findings. *The responsibility of the scientific and technical societies to encourage such participation receives special emphasis.*

Finally, large-scale experiments that involve large populations and the use of advanced technologies are necessary for the fulfillment of increasingly diverse needs; such experiments constitute exploratory development as well as research, and they require special provisions for planning and funding. We recommend that the *federal government establish a single group to (a) plan a unified program of critical experiments of operational scale in scientific and technical communication and (b) find, guide, and support contractors in the conduct of such experiments.*

The studies, research, and experiments that we have explicitly advocated are directed only to the most urgent needs; a continuing flow of work on a wide variety of problems is essential to progress. Our recommendations are intended merely to serve as points of departure and to challenge increased attention and effort.